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An Update of the Educational Attainment Model for a Minor Child*

John Kane and Lawrence M. Spizman

I. Introduction

In our 1992 paper (Spizman and Kane, 1992) an ordered probit estimation technique was used to predict the lost earning capacity of a wrongfully injured minor child. Prior to this paper the methodology of establishing the lost earning capacity was to apply the average earnings for each educational group (high school, some college, college, graduate school etc) to the wrongfully injured child. There was no method of determining the probability of the injured child attaining the educational level associated with the average earnings for that educational group. The ordered probit educational attainment model (the SK model) provided a solution to this problem by estimating the probabilities of alternative levels of educational attainment of an injured child based on familial and demographic characteristics. These characteristics included gender, race and parents' educational levels. By combining these estimates with information concerning expected earnings for each potential level of educational attainment, the present value of the child's expected lifetime earning stream can be estimated.[1]

Gill and Foley (1996) modified the original SK estimates by adding additional variables and utilizing a different sample population. The purpose of this paper is to update both studies by including new data that did not exist when either study was completed.

II. Why an Update?

The initial SK study utilized data from The National Longitudinal Study of the High School Class of 1972 (NLS72). While the NLS72 is a rich data set, the National Longitudinal Survey of Youth (NLSY) is even richer. Since all respondents in the NLS72 sample had completed high school, the SK model could not predict the probability that an individual will complete high school.[2] Gill and Foley (1996) remedied this problem by utilizing NLSY data from 1979 through 1992 to estimate a variation of the SK model. The NLSY sample included information on individuals who did not complete high school. They also expanded the list of variables to include parents' occupation, family composition, number of siblings, the religion in which an individual was raised, and variables that serve as proxies for the amount of reading that took place among the adults in the household (newspaper subscriptions, magazine subscriptions, and the presence of a library card in the household).

Gill and Foley's re-estimation and expansion of this model validated the SK model by showing the robustness of the model's results. The Gill and Foley (GF) study

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* Professors of Economics at the State University of New York at Oswego, Oswego, New York. The Authors would like to thank James Rodgers and Andrew Gill for comments and suggestions on an earlier draft of this paper that was presented at the 2001 Eastern Economic Association Meetings.

[1] William Hardy (1993) provides an alternative approach of forecasting the educational attainment of a child. This method relies on data from the General Social Survey, compiled by the National Opinion Research Center.

[2] This problem was recognized and discussed in the original 1992 paper.

used NLSY data collected from 1979 through 1992. The original sample included individuals who were between 14 and 21 years of age at the start of 1979[3]. While the NLSY data used in the GF study offers the advantage of providing information on individuals who had not completed high school, it does not contain completed educational attainment for those who completed their highest level of education after 1992. Those individuals who were 14 years old in 1979 would have been only 27 in 1992. Even with continuous educational enrollment, many individuals working towards a Ph.D. degree would not have completed this degree by age 27. Those who spent several years in the military to assist in the financing of their education might have not finished master's level programs by this age. Since many MBA programs require several years of work experience, many individuals intending to complete such a degree would also not have attained this degree by this age. Those nontraditional students who spent some time at work or in childrearing before completing their education would also, in many cases not have completed their education by 1992.

Today, however, the NLSY provides 6 additional years of data on the educational attainment of these individuals. This additional timespan makes it possible to provide a better estimate of completed educational attainment. The 14-year old respondents in 1979 would have been 33 years old in 1998, while the 21-year old 1979 respondents would have been 40 years old. In 1998 there were 15,546,000 people attending college, of these 1,266,000 (8.1%) were between the ages of 30 to 34.[4] The statistics are even more dramatic for college students between the ages of 35 to 44. In 1998, 10.64% (1,655,000 students) of all college students were between the ages of 35 to 44.[5] Thus, 18.74% of all enrolled college students were between the ages of 30 and 44.

These statistics indicate that human capital investments often occur later in life. This certainly was the case for a substantial proportion of the NLSY respondents:

- in 1993, 119 individuals reported a change in the level of highest educational attainment since their previous interview,
- in 1994, 108 individuals reported a change in the level of highest educational attainment since their previous interview,
- in 1996, 162 individuals reported a change in the level of highest educational attainment since their previous interview, and
- in 1998, 151 individuals reported a change in the highest level of educational attainment since their previous interview.

Thus, there were a total of 540 changes in educational attainment reported among the 8399-9011 individuals interviewed during the follow-up surveys conducted between 1993 and 1998.

Because of this upper truncation in the results reported by GF, it is important to update the estimates to provide a more accurate prediction of educational attainment probabilities. Six additional years of data would capture the completed educational attainment of many individuals who were attending college and receiving advanced degrees after 1992, a time period not included in the GF study.

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[3] *NLSY79 User's Guide 1999*, p. 15.

[4] *Enrollment Status of the Population, Selected Educational Characteristics*. Source: U.S. Census Bureau, Population Division, Education & Social Stratification Branch, http://www.census.gov/population/socdemo/school/report98/tab01.pdf

[5] Of the 44,346,000 people between the ages of 35-44 in 1998, 3.7% were enrolled in college.

III. The Model

As specified in the original SK paper, the ordered probit specification is given by:

1. $$Z_i = X_i\beta + u_i$$

Where X is a vector of family background and demographic variables that influence the unobserved variable Z_i (which represents the costs and/or benefits of different levels of education).

It is assumed that each individual decision to acquire their optimal educational level based on the following rule:

Individual *i* acquires:

less than a high school education if $Z_i \leq 0$
high school diploma or GED if $0 < Z_i \leq \mu_1$
1 - 3 years of college if $\mu_1 < Z_i \leq \mu_2$
a 4 - year college degree if $\mu_2 < Z_i \leq \mu_3$
a Master's degree if $\mu_3 < Z_i \leq \mu_4$
a Ph.D. (or equivalent) if $Z_i > \mu_4$

Since Z_i is unobservable, an indicator variable Y_i is used to show the actual level of education for each individual in the sample. (Zero for less than high school degree, 1 for high school degree up to 5 for advanced degree.)

Table 1 shows the estimated probability of the injured minor child reaching a given educational level using the estimated coefficients for the ordered probit model in equation 1.

Table 1

Probabilities of Alternative Educational Levels

Outcome	Probability*
Less than High School Degree	$\Phi(-\hat{Z}_i)$
High School or GED Degree	$\Phi(\mu_1-\hat{Z}_i)-\Phi(-\hat{Z}_i)$
1-3 Years of College	$\Phi(\mu_2-\hat{Z}_i)-\Phi(\mu_1-\hat{Z}_i)$
4 Year College Degree	$\Phi(\mu_3-\hat{Z}_i)-\Phi(\mu_2-\hat{Z}_i)$
Master's Degree	$\Phi(\mu_4-\hat{Z}_i)-\Phi(\mu_3-\hat{Z}_i)$
Ph.D. Degree (or equivalent)	$1-\Phi(\mu_4-\hat{Z}_i)$

- $\Phi(\cdot)$ is the cumulative density of the standard normal distribution.

Upon predicting the above probabilities, the lifetime earnings streams of the minor child are then estimated based on population averages for the particular educational category.

IV. The Data

The NLSY is a national sample of 12,686 individuals who were initially interviewed in 1979. Sample attrition had shrunk this sample to 8,399 by the 1998 interview. After eliminating individuals with missing data on key variables, a sample of 7,023 individuals is used for estimation purposes. This sample size is close to the 7,207 observations used in the GF study and the 7,862 observations used in the original SK study.

Table 2 provides descriptive statistics for males and females.[6] A comparison of our results with those of GF indicates a few prominent discrepancies. The most critical are the substantial differences in the levels of education attained in the two samples. We find that in 1998, a substantially smaller proportion of individuals had not completed either high school or a GED. In 1998, 9.3% of males and 7.67% of females reported not completing either a high school degree or GED. Gill and Foley found proportions for this variable of 17.9% and 15.7% for females using 1992 data.[7] In the current study, the proportion of the male and female subsamples with a high school degree or GED were 57.6% and 56.0%. GF found 43.4% and 41.7% proportions for males and females respectively on this variable. Thus, it appears that we find a larger share of the population with a high school degree as their highest level of educational attainment. We find a substantially smaller share of the population with 1-3 years of college and a larger share with a bachelor's degree. As expected, we find that a larger proportion of the population report master’s and PhD (or equivalent) degrees.

We also find a somewhat larger proportion of blacks in our sample than was present in the GF study. This may be due to differences in sampling weights or differences in response rates on more recent surveys on questions dealing with the educational variables used in the current study.

Since the NLYS79 data does not contain a single variable that corresponds directly to the dependent variable in this model, it is worth commenting on the process used to compute this variable.[8] The NLS79 data set collects two variables that characterize the level of educational attainment: highest degree attained and highest grade completed. Since the variable of interest is degree attainment in this model, we used the latest report of degree attainment by the respondent to define this variable. The responses to the degree attainment variable are used to define educational outcomes in a straightforward manner with only two exceptions:

1. An individual is listed as not completing high school if they do not report the attainment of a high school degree, GED or higher level of degree, and
2. An individual is listed as completing some college if the individual:
   - reports a high school degree and 13-15 years of schooling, or
   - reports an associate’s degree as the highest level of educational attainment.

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[6]As in GF, sample observations are weighted in the calculation of descriptive statistics to take into account the oversampling of minorities in the NLSY sample. In this study, we used the 1998 sampling weights.
[7]There are two possible explanations for this discrepancy. One is the completion of a high school degree, or more likely a GED (given the ages of the respondents), between 1992 and 1998. A second possibility is that more recent survey data may have filled in missing observations on educational attainment for a larger proportion of high school graduates.
[8]Correspondence with Andrew Gill indicates that an equivalent process was used to construct the educational attainment variable in the GF study.

Table 2

Description of Variables and Estimated Means[9]

Variable	**Description**	**Males**	**Females**
Highest Degree			
No HS degree	=1 has not completed either a high school diploma or a GED	0.093	0.077
High School	=1 if either a high school diploma or a GED	0.576	0.560
Some College	=1 if 1-3 years of college or an Associate's degree	0.069	0.102
Bachelors	=1 if the respondent reports a BA or BS degree	0.190	0.196
Masters	=1 if the respondent reports a Master's degree	0.050	0.057
PhD	=1 if the respondent reports a Ph.D or equivalent	0.022	0.009
Hispanic	=1 if Hispanic	0.049	0.052
Black	=1 if Black	0.134	0.146
Urban14	=1 if lived in a town or city when 14 years old	0.779	0.779
Mother's Education			
High School	=1 if the respondent's mother completed 12 years of schooling.	0.482	0.449
Some College	=1 if the respondent's mother completed 13-15 years of schooling	0.115	0.106
College	=1 if the respondent's mother completed 16 or more years of schooling	0.097	0.098
Father's Education			
High School	=1 if the respondent's father completed 12 years of schooling	0.336	0.342
Some College	=1 if the respondent's father completed 13-15 years of schooling	0.118	0.096
College	=1 if the respondent's father completed 16 or more years of schooling	0.184	0.166
Adult's Occupation			
Professional	=1 if either the adult male or female present in the household when respondent was 14 worked in a professional or managerial job	0.301	0.289
Sales or Clerical	=1 if either the adult male or female present in the household when respondent was 14 worked in a sales or clerical job	0.240	0.239
Religion Raised			
Baptist	=1 if Baptist	0.235	0.255
Protestant	=1 if the respondent reported one of the following categories: Protestant, Episcopalian, Lutheran, Methodist, or Presbyterian	0.300	0.284
Catholic	=1 if Roman Catholic	0.344	0.335
Jewish	=1 if Jewish	0.016	0.016
Other	=1 if other religion not specified	0.102	0.109
Only Child	=1 if the respondent reported no siblings	0.033	0.029
Both Parents	=1 if the respondent lived with both mother and father when 14-years old	0.774	0.762
Newspapers (NP)	=1 if a household member received NP regularly when respondent was 14	0.857	0.837
Magazines (MAG)	=1 if a household member received MAG regularly when respondent was 14	0.684	0.670
Library Card (LC)	=1 if any household member had a LC when the respondent was 14 years old	0.754	0.787
Observations		3411	3612

[9] Since the original sample oversampled minority groups, the descriptive statistics reported above are computed using the 1998 sampling weights to provide estimates of population statistics. The descriptive statistics reported by Gill and Foley were also weighted estimates.

Table 3

Ordered Probit Equation – Model I

Variables	Males	Females
Constant	0.802*** (14.204)[10]	0.976*** (16.803)
Hispanic	-0.106* (-1.827)	0.013 (0.245)
Black	-0.063 (-1.281)	-0.041 (-0.895)
Urban14	-0.009 (-0.178)	-0.110** (-2.217)
Mother's Education		
High School	0.410*** (8.212)	0.458*** (9.743)
Some College	0.687*** (8.630)	0.675*** (8.913)
College	1.022*** (11.814)	1.036*** (11.995)
Father's Education		
High School	0.277*** (5.302)	0.304*** (6.237)
Some College	0.575*** (7.879)	0.556*** (6.973)
College	0.968*** (13.402)	0.874*** (12.463)
μ_1	2.005*** (54.237)	1.963*** (52.909)
μ_2	2.273*** (56.890)	2.341*** (58.071)
μ_3	3.252*** (64.712)	3.327*** (68.086)
μ_4	3.884*** (56.550)	4.210*** (51.552)
Chi-Squared	828.903***	792.601***

*significant at the 0.1 level

**significant at the 0.05 level

***significant at the 0.01 level

[10] *t*-statistics in parentheses.

Table 4

Ordered Probit Equation – Model II

Variables	Males	Females
Constant	0.134 (0.425)[11]	0.189 (0.209)
Hispanic	-0.072 (-1.118)	0.016 (0.266)
Black	0.083 (1.435)	0.140** (2.563)
Urban14	-0.008 (-0.156)	-0.112** (-2.224)
Mother's Education		
High School	0.340*** (6.543)	0.389*** (8.030)
Some College	0.583*** (7.083)	0.552*** (7.080)
College	0.898*** (10.126)	0.818*** (9.089)
Father's Education		
High School	0.244*** (4.579)	0.250*** (5.064)
Some College	0.464*** (6.197)	0.423*** (5.173)
College	0.788*** (10.340)	0.645*** (8.841)
Adult's Occupation		
Professional	0.281*** (4.882)	0.390*** (7.323)
Sales or Clerical	0.148*** (2.797)	0.126** (2.428)
Religion Raised		
Baptist	0.399 (1.275)	0.492 (0.545)
Protestant	0.541 (1.716)	0.734 (0.812)
Catholic	0.489 (1.551)	0.661 (0.732)
Jewish	0.926** (2.487)	1.271 (1.376)
Other	0.494 (1.553)	0.524 (0.580)
Only Child	0.175 (1.503)	0.228** (2.063)
Both Parents	0.225*** (5.076)	0.194*** (4.627)
μ_1	2.034*** (53.771)	1.996*** (52.518)
μ_2	2.305*** (56.400)	2.384*** (57.344)
μ_3	3.297** (64.667)	3.398*** (67.351)
μ_4	3.936*** (56.340)	4.295*** (52.359)
Chi-Squared	905.485***	909.838***

*significant at the 0.1 level

**significant at the 0.05 level

***significant at the 0.01 level

[11] *t*-statistics in parentheses.

Table 5

Ordered Probit Equation – Model III

Variables	Males	Females
Constant	-0.090 -(0.299)[12]	0.127 (0.132)
Hispanic	0.012 (0.177)	0.084 (1.333)
Black	0.136** (2.315)	0.176*** (3.196)
Urban14	-0.051 (-0.992)	-0.161*** (-3.131)
Mother's Education		
High School	0.291*** (5.515)	0.357*** (7.342)
Some College	0.521*** (6.233)	0.496*** (6.286)
College	0.807*** (9.005)	0.755*** (8.381)
Father's Education		
High School	0.204*** (3.838)	0.212*** (4.246)
Some College	0.403*** (5.274)	0.367*** (4.480)
College	0.734*** (9.523)	0.593*** (8.056)
Adult's Occupation		
Professional	0.224*** (3.820)	0.356*** (6.672)
Sales or Clerical	0.095* (1.764)	0.088* (1.694)
Religion Raised		
Baptist	0.360 (1.214)	0.374 (0.388)
Protestant	0.466 (1.558)	0.570 (0.591)
Catholic	0.417 (1.393)	0.505 (0.524)
Jewish	0.841 (2.357)**	1.108 (1.126)
Other	0.458 (1.514)	0.368 (0.381)
Only Child	0.179* (1.487)	0.225** (2.034)
Both Parents	0.200*** (4.478)	0.182*** (4.483)
Newspapers	0.118** (2.231)	0.065 (1.315)
Magazines	0.272*** (5.805)	0.181*** (3.977)
Library Card	0.229*** (4.868)	0.232*** (4.927)
μ_1	2.072*** (53.353)	2.020*** (52.511)
μ_2	2.3475*** (55.997)	2.411*** (57.188)
μ_3	3.351** (64.018)	3.430*** (66.934)
μ_4	3.995*** (56.567)	4.327*** (55.504)
Chi-Squared	990.670***	965.740***

*significant at the 0.1 level

**significant at the 0.05 level

***significant at the 0.01 level

[12] *t*-statistics in parentheses.

V. Empirical Results

Different family background and demographic variables can be used in the vector X in equation 1. We tested the three different variations of this model that were presented in GF. Model I, roughly equivalent to the original SK model, includes only variables on race, geographical location, and parents' educational attainment.[13] Dummy variables for parents' occupation, religion, the absence of siblings, and for a two-parent household when the child was 14 years old are added to those in Model I to form Model II. Model III consists of all of the variables in Model II and dummy variables capturing newspaper subscriptions, magazine subscriptions, and the presence of a library card in the household.[14] Table 3, 4, and 5 contain estimates of the ordered probit equation models corresponding to models I, II, and III.[15] A positive (and statistically significant) coefficient indicates that an increase in the level of the variable raises the probability that an individual will complete at least a high school degree.[16] Living in an urban area is significant and positive for females only. If the household had adult professional or managerial workers, their children are more likely to possess at least a high school degree. On the other hand, if the adult in the household was in a sales and clerical occupations, it would only increase the probability that a female will attend college. Religion does not have an impact on attaining education beyond a high school level except for Jewish males. This is different than the GF study which showed all religions having a positive impact on attending at least some college.

Being an only child or having both parents living with you had a positive impact of attaining a higher level of education. The availability of reading material in the house as well as a library card generally, as in GF, had a positive and significant impact, the only exception was newspapers for females.

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[13] All empirical results reported below were computed using the default algorithm in LIMDEP for the computation of an ordered probit model. Correspondence with Andrew Gill indicated that the same estimation procedure was used in the GF study.

[14] Model I is applicable by forensic economists in the widest variety of cases since it only includes variables that are likely to be known in every case. The more elaborate specifications used in Models II and III require information that may not always be available to a forensic economist, particularly in cases in which the child is injured and awards must be made prior to the individual reaching age 14 (the age at which several of the additional variables are measured). When such information is available, these more elaborate specifications are more appropriate.

[15] One minor difference between our estimation procedure and that used by Gill and Foley is that they rely on a weighted maximum likelihood estimator for this model while we use an unweighted maximum likelihood estimator. The argument for a weighted estimator is that better estimates of population parameters may be derived if each sample observation is weighted by the population proportions of individuals with similar demographic characteristics. Such an argument, however, has merit only if the equation parameters differ across these demographic groups. In such a situation, however, a single equation model would be inappropriate. If the population parameters are constant across all demographic groups (with the effects of race and other variables being captured by dummy variables), then there is no advantage in applying a weighted estimator. (It should be noted that we investigated the effect of using a weighted estimator and found only trivial differences in parameter estimates.)

[16] This also indicates an increase in the probability of the individual falling into the category of a Ph.D. or above. The effect on the specific categories of a high school degree, a bachelor's degree, or a master's degree can only be addressed in specific cases.

VI. Comparison of Predicted Educational Attainment

GF compare our original model with their expanded model using estimates of two versions of the model (one that roughly corresponded to our model) and one with an expanded set of variables. They based their comparison on the atypical case in which all of the dummy variables were zero. This case involves:

- a boy,
- with white parents,
- living in a rural area,
- neither parent completed high school,
- no adult in the household when the respondent was 14 worked in a professional, sales, or clerical occupation,
- did not report a religion,
- had one or more siblings, and
- who did not live with both parents at age 14.

Since all of the dummy variables are equal to zero in this case, a comparison is based on the intercept term from the ordered probit equations. In the GF study (Model II), the male intercept was -0.359. In the current study, the male intercept is .134. Table 6 reports predicted probabilities for alternative levels of education for our original model (as adjusted by Gill and Foley), the GF model, and our re-estimated version of the GF model).

Table 6

Outcome	GF Model II Probability	SK Updated Model II Probability
Less than High School	64.0%	44.67%
High School Degree	32.2%	52.46%
Some College	3.0%	1.37%
Bachelor’s Degree	0.76%	1.42%
Master’s Degree	0.02%	.078%
Ph.D. or Equivalent	0.003%	.007%

Table 7 uses the same model as table 6 but now the example uses a white male child with two parents possessing some college education with at least one parent being a professional or managerial employee. The differences in the probabilities of educational attainment in the case illustrated in Table 7 are similar to the changes appearing in table 6.[17]

Table 7

Outcome	GF Model II Probability	SK Updated Model II Probability
Less than High School	18.73%	7.19%
High School Degree	51.29%	64.45%
Some College	17.84%	8.41%
Bachelor's Degree	10.89%	16.64%
Master's Degree	.981%	2.66%
Ph.D. or Equivalent	.27%	.67%

Conclusions

GF provided an enhancement to the SK model by demonstrating that the estimation of an ordered probit model using a sample that only contains high school graduates can substantially affect estimated probabilities of education attainment. The current study uses an educational attainment variable that is a better measure of completed educational attainment. As the sample population ages individuals acquire more human capital, affecting the probabilities of educational attainment (as indicated by the examples illustrated in tables 6 and 7). These tables shows that an individual's probability of remaining a high school dropout is reduced while the probability of attaining a high school education increases as time passes. The probability of not finishing a college degree, once started, declines since many individuals eventually complete their degrees. More education is acquired beyond the Bachelor's Degree. Ignoring the six additional years of data since the GF study would underestimate the probability of attaining higher levels of education and thus reduce the losses. The results of this study further supports the robustness of the SK educational probability model.[18]

[17] In both our and Gill and Foley's papers estimates of economic losses were provided. Thus we did not feel it necessary to include such examples in this paper since it is somewhat obvious that higher levels of education will increase income. Thus, ignoring six additional years of data would underestimate the economic damages. Nevertheless, we did estimate economic damages for the two examples assuming the it was a 12 year old who was injured in 1997 and had a work-life expectancy to age 65 using age/earning profile for income and deducting residual earnings. Table 6 using the Gill Foley model showed a undiscounted loss of $984,733 while our updated version showed a loss of $1,007,953. The loss in the example of table 7 using GF showed a loss of $1,130,524 while the updated model had losses of $1,187,515. For those already using earlier versions of this model there is no significant time commitment to updating the probabilities. The percentage difference in lost earnings justifies using the updated version.

[18] In a 1998 paper (Spizman and Kane, 1998), we addressed the degree to which our 1992 paper, in conjunction with the Gill and Foley (1996) refinement, would satisfy the standards in *Daubert v. Merrell Dow Pharmaceutical*. Based on that analysis, it would appear that the current work would increase the

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acceptability of this methodology under *Daubert* standards. This is especially important in light of the decision of the United States Supreme Court in *Kumbo Tire Co. v Carmichael* (1999), making it clear that *Daubert* standards will apply to all types of analysis.